ADDIS ABABA SCIENCE & TECHNOLOGY UNIVERSITY
SCHOOL OF CIVIL ENGINEERING & CONSTRUCTION TECHNOLOGY

DEPARTMENT OF CONSTRUCTION TECHNOLOGY & MANAGEMENT

OPPORTUNITIES AND CHALLENGES OF IMPLEMENTING BUILDING INFORMATION MODELING IN ADDIS ABABA INTEGRATED HOUSING DEVELOPMENT PROJECT

A Project Submitted To The School Of Civil Engineering And Construction Technology Management In Partial Fulfillment Of The Requirement For The Degree Of Master Of Engineering Meng In Construction Technology And Management

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ADDIS ABABA ETHIOPIA

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Approval Page

This Meng Project entitled with “the benefits of kaizen in construction industry” has been approved by the following examiners in fulfillment of the requirement of the degree of Master of Engineering in Construction Technology and Management.

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Acronym and Abbreviations

BAS :Building automation system

CM: Construction manager

CNC :Computer Numerical control

E & O: Errors and omission

IFC :Industry Foundation classes

IPD : Integrated project delivery

KPIS :Key Performance Indicators

MEP :Mechanical electrical plumbing

RFID: Radio Frequency Identification

VDC : Virtual design and construction

Abstract

Building Information Modeling "BIM" is becoming a better known established collaboration process in the construction industry. Owners are increasingly requiring BIM services from construction managers, architects and engineering firms. Many construction firms are now investing in "BIM" technologies during bidding, preconstruction, construction and post construction. The goal of this paper is to understand the uses, opportunity and challenge of BIM for construction management for Addis Ababa Housing Development project. There are three objectives to this paper. First is to show the current uses of BIM in the Architectural / Engineering / Construction / Facility Management industry in developed country. Second to identify the benefit and challenge to implement BIM under better understanding and legal barriers to collaborative BIM processes in this project. Third, assesses the current understanding level of BIM in different public and privet construction organization in our country. The research was conducted through literature review, journals, and interviews. First, the research identified the uses of Building Information Modeling for preconstruction, construction and post construction phases. Then, the paper examined the uses, benefits and challenge of BIM in the construction of a research facility. Finally, the project concluded with project analysis discussion on the use, advantages and setbacks of BIM and its tools.

KEY Words: Building Information Modeling, Parametric Elements, Construction Industry

CHAPTER ONE

INTRODUCTION

1.1BACKGROUND

In earlier times, the architect was the mastermind behind the project. These projects were small in size and simple to execute. Hence, the architect himself communicated his ideas about planning, design and construction on-site. His was the only mind which could solve problems, address issues, and had all the information. Later, the projects grew larger and more complex. It was then that the notions of the architect were expressed to the builders and owners in the forms of models and drawings. Gradually, there was removal of master builder from site and communication of design gained importance. Specialty fields developed and the scope of work in projects increased. Nature of the problems faced during projects hasn't changed, but their complexity has. The project still needs to be coordinated well and it is a difficult role to be played by one person due to various approaches to project delivery methods. This is when BIM is needed to manage the essential building design and project data in digital format throughout the building's life-cycle i.e. in design, construction and management phases. Earlier, CAD systems were used to produce drawings and three-dimensional images. Now the focus has shifted to the data itself. BIM has following components: those with behavioral data, those that build (with intelligent digital representations), those with consistent and non-redundant data, and those with coordinated data. All of these enable the architects to catch and avoid the costly mistakes and in a way, virtually try the building before incurring the huge expense of building it in real-time (McGraw-Hill Construction, 2008).

In addition to this, the traditional construction project delivery approach, Design-Bid-Build, fragments the roles of participants during design and construction phases. In other words, it hinders the collaborative involvement of the general contractor or the construction manager during the design phase of the project. Secondly, the use of common and traditional two dimensional CAD drawings does not promote a true collaborative approach. Architects and engineers produce their own fragmented CAD documents to relay theirs designs to owners and contractors. These drawings are not integrated and usually pose conflicts of information which result in inefficiency in labor productivity. The estimators need to count and generate their own quantity take offs based on the produced CAD documents. Moreover, the 2D CAD approach does not promote the integration of the drawings with schedule and cost.

Furthermore, the construction workers on the average are paid lower wages than the manufacturing industry. Therefore, firms do not have as much of an incentive or the resources to invest money in research and development of technology because of its high risks and costs. When the new methods and technologies are used, they are applied per project basis and are not adapted quickly in the construction industry.

One of the first steps towards the use of 3D technology in the construction industry was initiated as a 3D solid modeling in late 1970s. During this time, manufacturing industry carried out product design, analysis, and simulation of 3D products. 3D modeling in the construction industry was hindered "by the cost of computing power and later by the successful widespread adoption of CAD" (Eastman, 2008). The manufacturing industry realized, spent more resources in technology and seized the "potential benefits of integrated analysis capabilities, reduction of errors, and the move toward factory automation". They worked together with modeling tool providers to reduce and eliminate the technological software setbacks .Recently; various BIM tools became readily available throughout the construction industry. This is a reward of construction industry's dedication to Building Information Modeling for the last 20 years (Eastman, 2008). Construction industry has come to a point to realize the true benefits of technological advancement. The labor efficiency gap can be closed via the Building Information Modeling concept. Therefore, it is the intention of this project to study BIM and its tools to determine benefits and setbacks it poses to construction managers at risk.

In this project, the uses of BIM which include visualization, 3D coordination, prefabrication, construction planning and monitoring, cost estimation and record model were discussed in detail. A.A housing project was presented to adapt the actual uses and benefits of BIM for the future 2nd GDP plan. This project concluded that although BIM tools do pose some shortcomings such as interoperability issues, the use of BIM is very beneficial to the construction managers.

1.2 STATEMENT OF THE PROBLEM

Uncoordinated and inefficient housing sector with insufficient structured work plan highly affect the integrated housing development program. Adoption of use of Building information modeling and implementation has resulted in the emergency of new knowledge and skill gaps within the program in the long run.

1.3 RESEARCH OBJECTIVES

1.3.1 General objective

Generate structured BIM adoption plan by Addis Ababa housing project. This is practically important because BIM implementation as an advanced technology driven process needs to be well structured and well managed as a condition of its success.1.3.2 Specific objectives

- Identify opportunity in implementation BIM in Addis Ababa integrated housing development project

- Identify challenge in implementation BIM in in Addis Ababa integrated housing development project
- To Show many business and legal barriers to collaborative Building Information Modeling processes.
- Identified the uses of Building Information Modeling for preconstruction, construction and post construction phases.
- Transform Building Information Modeling into performance assessment and improvement tools
- Analysis on the use, advantages and setbacks of Building Information Modeling and its tools.

1.4 RESEARCH QUESTION

Industry's far-ranging expectations from BIM tools and workflows and the challenges of meeting these expectations uncover numerous knowledge gaps, each of which warrants investigation. Rather than investigating each gap individually, this study espouses a holistic view and adopts two complementary research questions:

Research question 1:

What is the knowledge structures underlying the BIM domain?

Research question 2:

How can these knowledge structures be harnessed to assist industry stakeholders to adopt BIM or improve their BIM performance considering case study of Addis Ababa housing project?

1.5. SIGNIFICANCE OF THE STUDY

Building Information Modeling (BIM) is an integrated process of generating and managing a building by exploring a digital model before the actual project is constructed and later during its construction, facility operation and maintenance. Therefore the significance of this research is:

- To identify the opportunity and benefit of implementation of BIM in the Addis Ababa Housing program.
- To avoid additional cost during construction.
- To identify the legal barriers to collaborative BIM processes
- To adopt the building industry digital technology and particularly the integrative use of BIM during the building lifecycle as it moves towards new approaches.

To recommend using BIM from conceptual design stage till the construction phase of the project, based on a single data source will improve overall construction management system.

CHAPTER TWO

LITERATURE REVIEW

2. AN OVERIEW OF BIM

The role and use of Building Information Modeling from the Construction Management point of view. First BIM is reviewed and defined. The uses of Building Information Model, and the Building Information Model software and integrators are also discussed mainly from a construction management perspective.

2.1 DEFINATION OF BIM

The Building Information Model is primarily a three dimensional digital representation of a building and its core characteristics. It is made of intelligent building components which includes data attributes and parametric rules for each object. For instance, a door of certain material and dimension is parametrically related and hosted by a wall.

Furthermore, BIM provides consistent and coordinated views and representations of the digital model including reliable data for each view. This saves a lot of designer's time since each view is coordinated through the built-in intelligence of the model.

In other words, Building Information Modeling (BIM) is the process and practice of virtual design and construction throughout its lifecycle. It is a platform to share knowledge and Communicate between project participants.

High quality 3D renderings of a building can be generated from Building Information Models. If the contractor only uses the model to better communicate the BIM concept in 3D and does not further use the built-up information in the Building information Model, then this is referred to as "Hollywood" BIM. Contractors may use the "Hollywood" BIM to win jobs. However, they do not seize the full potential value of Building Information Modeling.

Sometimes, Building Information Modeling is practiced internally within only a single organization of the project and not shared with the rest of the organizations. This is referred to as "lonely" BIM. For example, an architectural firm may decide to design a Building Information Model, and use it for visualization and energy analysis. Architect's firm may even have an internal collaboration. However, the architect may decide to provide the drawings in two dimensions and restrict the Building Information Model access. This would hinder the participation of the construction manager (CM) unless the CM creates a new model. (Vardaro, 2009).

A more collaborative approach would be the "social" BIM which enables the sharing of the model between the engineer, architect, construction manager, and subcontractors. At the BIM meetings, the construction manager and subcontractor can provide their expert construction knowledge to the design team. Moreover, the construction manager can use the building information models to generate constructability reports, coordinate, plan, schedule and cost estimate. After collaboration efforts such as mechanical, electrical, plumbing (MEP) coordination among the contractors, engineers and architects are completed, specialty contractor can then use the information from Building Information Model to prefabricate products.

Another approach known as “intimate” BIM is realized when the construction manager, design team and owner contractually share risk and reward. This is made possible complete BIM-enabled integrated project delivery. Intimate” BIM as well as “social” BIM encourages teams to collaboratively produce better drawings, reduce time and cost in a project. BIM could be read as Building Information Model or Building Information Modeling (Granroth, 2011). This might seem like a trivial difference, but it is a major obstacle when it comes to finding a common definition. This issue could be seen in American national institute of building sciences’ definition of BIM:

“A BIM is a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward. … A basic premise of BIM is collaboration by different stakeholders at different phases of the lifecycle of a facility to insert, extract, update, or modify information in the BIM to support and reflect the roles of that stakeholder. The BIM is a shared digital representation founded on open standards for interoperability.” NIBS (2007)

In this definition it appears like the second BIM is about the process of creating a model, also known as building information modeling, whilst the three other seems to refer to BIM as the model.

2.2 THE SCOPE OF BIM

What is needed in order to be BIM seems heavily individual were a common interpretation of BIM is missing. However the U.S. national institution of building science (NIBS, 2007) has divided the BIM scope into three commonly used categorizations; BIM as a product, BIM as a process, and BIM as a facility life cycle management tool.

- BIM as a product – Building Information Model.
- BIM as a collaborative process – Building Information Modeling.
- BIM as a facility lifecycle management tool – Building Information Modeling.

2.2.1 BIM as a product

BIM as a product refers to the actual model as an intelligent digital representation of data about a facility (NIBS, 2007). In order to qualify as intelligent is not just a 3D representation based on objects enough. It also has to include some information or properties beyond the graphical presentation and it is primarily this information in BIM that leads to the biggest benefits for the industry (Granroth, 2011). The view of

BIM as a product is sometimes called the underdeveloped view of BIM due to that it just considers the model (WSP group, 2011).

2.2.2 BIM as a process

The view of BIM as a process considers the process of developing a BIM model (the BIM product) and using it in order to reach project efficiency (WSP group, 2011). At this level of BIM also the social aspects such as; synchronous collaboration, coordinated work practices, and institutional and cultural framework are being dealt with. Most companies that today state that they are working with BIM are looking at this level of BIM and focus on finding processes that enable them to deliver good and profitable projects. The key point from this view is that BIM is a marriage between technology and a set of work processes.

2.2.3 BIM as a facility lifecycle management tool

The last and most demanding of these views is BIM as a facility lifecycle management tool. This view sees BIM as management tool, by focusing on a sustainable, verifiable, and repeatable information based environment in order to guarantee well-understood information exchanges, workflows, and procedures, throughout the building lifecycle (NIBS, 2007). Due to this long term perspective is this view extra interesting for client organizations.

2.2.4 Interpretation in the report

In this report BIM is mainly seen as a facility lifecycle management tool. However, it is important to recognize that the BIM model and BIM process are steps needed in order to be able to use BIM as a facility lifecycle management tool. This view then means that implementation of BIM should be considered as an innovation were organizational and strategic choices needs to be aligned with change decisions. Facilities management implies those who from the client company have the managerial responsibility to make sure that the customers' operations can run smoothly.

2.3 BENEFITS OF BIM

BIM and IPD afford manufacturers, designers and integrators advantages in design efficiency and quality control. A single, connected model improves communication within the design and construction teams and the parametric elements of the model create a robust database. The building owner and facility manager can utilize the data within the model during the occupation of the building. Harvesting the information in that database can help everyone be more efficient and also create new opportunities for revenue expansion. Modeling, instead of drawing, is the new paradigm, encouragement new cooperation, innovation and building life-cycle savings. Some of the benefits of BIM:

a. Modeling vs. 2D Drafting

Building modeling improves over 2D drafting by allowing designers to view the building and its contents from all angles, and revealing problems at earlier stages to allow for correction without costly change orders. Truly parametric design saves time by creating and editing multiple design portions simultaneously. Sections, elevations and three dimensional views can be created instantly, reducing the need for check plots. Changes to any one of these elements affect all of the others, including materials, costs and construction schedules. The two-dimensional printed documentation becomes the quick and accurate by product of parametric design.

b. Parametric Elements

Parametric elements allow for the creation of large, versatile sets of building components with little effort. One generic element can serve as a template with predefined ranges of characteristics. This parametric data allows the element to be easily reconfigured to suit the unique requirements of implementation in various areas of the model.

The following are examples of parametric data and element relationships:

- Chairs are arranged evenly across an elevation. If the length of the elevation is changed then the equal spacing of the chairs will be maintained. The data parameter in this case is proportional.
- The edge of an electrical box is related to an interior wall such that when the wall is moved, the electrical box remains connected. In this situation, the parameter is association or connection.
- The parametric data in a collaborative model can also save time during the design process and the construction administration phase by improving coordination and reducing the need for additional site visits, printing and manual drawing checks. Changes and additions to building elements update simultaneously across all views, schedules and sheets.

c. Change Management

Parametric elements that are changed in one location change in all corresponding views and locations. Warnings and flags can also be created between elements to allow managers to see element changes in any view. These warnings can be arranged into an element change report to facilitate coordination.

d. Leveraging Data

The Building Information Model is a database that contains manufacturer information, pricing, physical information (such as weight, size, and material finish) and electromechanical data for many of the devices in the building. Leveraging this data means that very accurate material schedules can be created from the parametric model elements and they will change automatically with visual component. Having accurate material schedules allows designers and integrators to project material usage before construction is complete and to create real-usage reports for building management after construction.

Additionally, this data contained in the model can be used to identify and create manufacturer available everywhere to simplicity with service, or if desired, reveal opportunities for manufacturer variety.

Parametric data can be used to populate any database application and extracted to create take-offs, usage reports, and in some cases, shortcuts for photo-real rendering applications.

e. Value-Added Tasks

A powerful BIM adopter can turn commodity lighting level recommendations into a value-added Lighting for AV Study service, with included 3D renderings to demonstrate the need for appropriate video-teleconferencing lighting. Accurate photometric studies that are focused on AV can be marketed as added service.

The availability of building information that is inherent to the model aids in the generation of reports that may be provided to the client as value-added services. Power and heat load calculations can be converted into green AV reports. These reports can also be generated from building power usage data after the building is occupied. Because accurate usage data can be collected and stored in the Building Information Model, new value can be added to predictive usage reports.

Room drawing snapshots to accompany a training manual can be transformed into an online training manual which includes a user experience walk-through video. New usage setups can be explored after occupancy, and new training demonstrations can be created and sold.

f. Improved Coordination

With BIM, detailed information about each building component is contained within its modeled element. BIM allows all team members easy access to information, such as power consumption and weight, to verify that the building element in question will be compatible with the components of the building for which they are responsible. BIM improves coordination among team members by making design changes, and all consequences of those changes, evident and available to all users of the model and to all parametric model elements. Design team members stay in sync with one another's progress, leaving no trade trying to play catch up after a release.

BIM makes it possible to quickly create sections and elevations of a room without the need to create them from scratch or ask the architect to provide sketches.

The synchronized and collaborative nature of BIM allows for earlier clash detection between the numerous members of the design team. When areas of conflict are identified earlier, conflicts over space allocation are initiated and resolved sooner. Earlier clash detection therefore shortens the time required for building design and reduces costs associated with correcting clashes that were undetected during design reviews. Interference detection with BIM is as simple as identifying the elements that need to be checked and running a report. Clash detections also happen as elements are moved or added.

g. Improved Accuracy and Efficiency

BIM affords integrators increased accuracy for quantity takeoffs. Metadata attached to objects allows for accurate counting and price modeling, improving the accuracy of bids and project pricing. Designers can enjoy receiving fewer requests for information and change orders. Integrator scheduling based on material availability and construction progress can be mapped visually. This allows project managers to quickly optimize construction schedules with ever-changing material deliveries, seasonal costs and availability.

BIM helps reduce errors and omissions (E&O) which should in turn reduce E&O claims and professional liability. A reduction in insurance costs, bonding fees and a positive impact on firm reputation should increase the number, scale and variety of opportunities available to design and integration firms.

h. Delivery Process Efficiencies

Design and drawing production requirements should evolve so that managers, designers and drafters spend less time developing designs and more time providing creative solutions for clients. The physical demand for the creation of multiple views of a building in 2D can be reduced to a short time with a BIM solution. A workflow shift should begin to occur in design departments following the adoption of BIM practices, moving away from lower-level drafting positions and toward the creation of more technical design positions. Electronic reviews of every portion of the building design including equipment schedules, room views, system designs, fabrication schedules, green building information, pricing and more are possible as BIM is the single repository for all of this information. With the possibility of full electronic reviews, delivery to the client can be expedited.

Virtual conflict resolution saves time and money over traditional conflict resolution by providing a clear and automatic view of conflicting issues and a quick demonstration of the resolution paths.

Parametric Building Information Models allow for the discovery of design errors early and significantly reduce the probability of extensive redesign. Model elements that are dependent upon one another maintain their relationships throughout changes to either element. For example, an electrical outlet in a wall will remain at the correct location in the wall if the wall is moved. The cost of repairing design errors increases as the project design progresses and the earlier discovery of these errors lessens schedule overrun from redesign.

i. Client Satisfaction

Visual verification of design intent and knowledge sharing through Virtual Design and Construction (VDC) and BIM make for happier clients. The rapid preparation and exchange of visual information mitigates the time needed for communicating complex ideas and allows more time to be creative for your clients, which should result in repeat business and excellent references.

j. Ongoing Technology Management

Technology professionals can use the information in a model to schedule routine maintenance, plan special events, tie to room scheduling applications and issue trouble reports to technology service personnel. The administration of service contracts can become more predictive and less reactive. Parts replacement becomes easier and quicker and maintenance can be completed with fewer errors.

k. Facility Management

BIM can link data from manufacturers, construction data and communications into one fully integrated and robust facility dashboard. Facility managers can use BIM to gather usage data, prepare maintenance schedules using predictive data, manage daily operations and plan for future purchases and construction additions. Full equipment data including operating parameters, usage data, predictive data, service history, replacement price and links to other manufacturer data, combined with a fully rendered 3D depiction of the equipment creates a powerful tool for facility managers.

2.4 USE OF BIM IN CONSTRUCTION MANAGEMENT

There are many uses of Building Information Modeling for each project participant. Table 1 depicts these uses for the planning, design (preconstruction), construction and operation (post construction) phases:

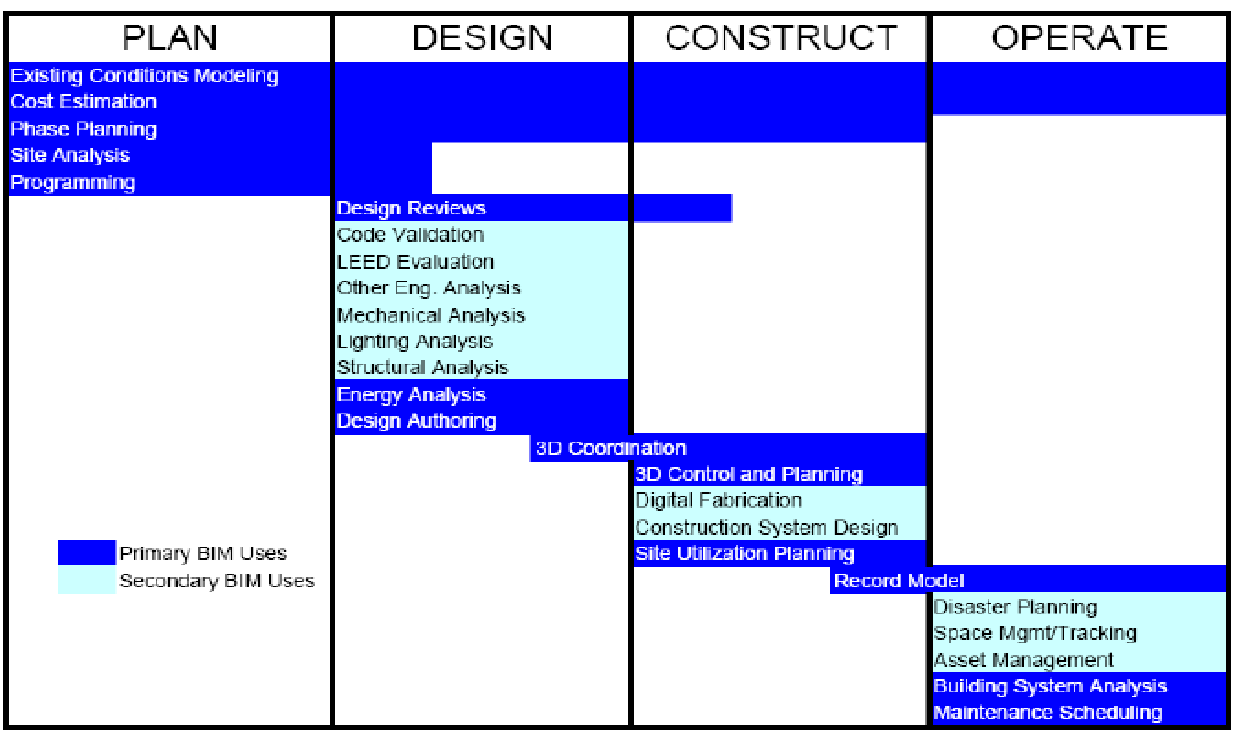

Table 1: BIM Uses throughout a Building Lifecycle (Messner, 2009)

During the design phase, the use of BIM can maximize its impact on a project since the ability to influence cost is the highest. The team can creatively come up with ideas and provide solutions to issues before problems become high cost impacts to the project. This can be realized through the cooperation and coordination of the entire project staff. Therefore, it is extremely important to have a good collaboration. The use of BIM especially enhances the collaborative efforts of the team. The architect and engineer can test their design ideas including energy analysis. The construction manager can provide constructability, sequencing, value and engineering reports. They can also start 3D coordination between subcontractors and wholesalers during early stages of design. The owner can visually notice if the design is what he is looking for. Overall, the BIM promotes the collaboration of all of the projection participants.

There are beneficial uses of BIM during the construction phase. However, the ability to impact the cost in a project reduces as the construction progresses. Several uses include sequencing, cost estimation, fabrication and onsite BIM.

During the post construction phase, maintenance scheduling, building system analysis, asset management, and space management and tracking , disaster planning, and record modeling can a record model can help to maintain the building throughout its lifecycle. Ideally, the building automation systems (BAS) which controls and monitors the use of mechanical and electrical equipment can be linked to the record model to provide a successful location based maintenance program. Furthermore, building system analysis including energy, lighting, and mechanical can be used to measure building's performance. Moreover, upgrades may be initiated to various equipment and components of the building.

2.4.1 Visualization

Building Information Modeling (BIM) is a great visualization tool. It provides a three dimensional virtual representation of the building. During the bidding phase of the project, the construction manager can provide renderings, walkthroughs, and sequencing of the model to better communicate the BIM concept in 3D. Visualization provides a better understanding of what the final product may look like. It takes away thought process of bringing the different traditional 2D views together to come up with the 3D view of a detail. Furthermore, virtual simulate such as laboratories or building envelope can be provided to the designer and the owner. This would help to visualize, better understand, and make decisions on the aesthetics and the functionality of the space. As depicted in figure 2 and presented in the BIM Opportunity Conference in San Diego, virtual mock ups can be used to review 3D shop drawing of the building envelope (Khemlani, 2011). The virtual simulate help to communicate and collaborate among the project participants. It promotes planning, and sequencing the curtain wall construction. Even though a virtual mock up (simulate) is cost efficient in comparison to a physical mock-up, a physical mock-up may still be required if a member such as casework drawer or an assembly of the building such as a curtain wall need to go through a series of physical tests. Hence, virtual mock-ups could become a good standard to initiate the mock up process and an actual mock-up may be necessary after the virtual mock up is approved.

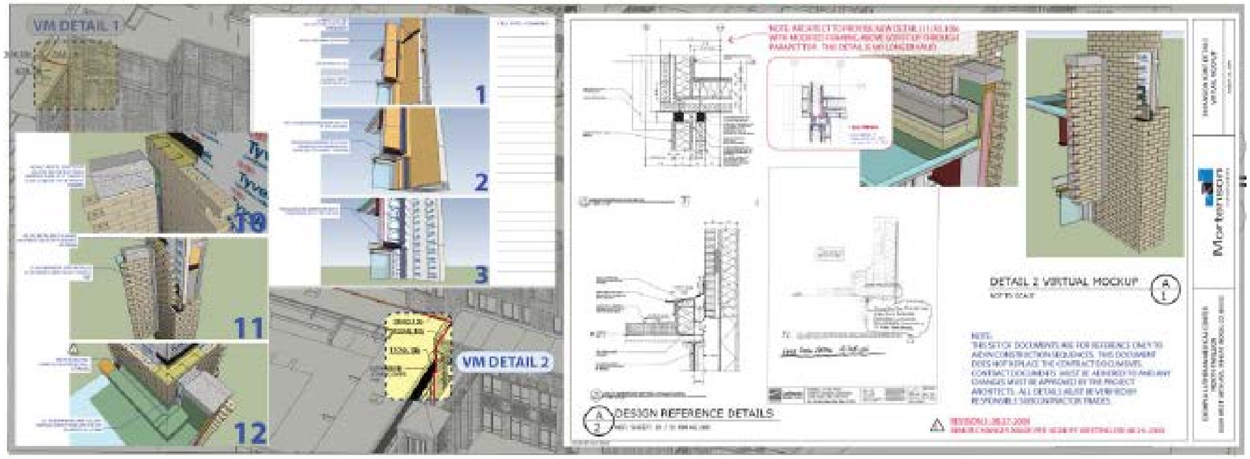

Figure 1: Exterior Envelope Virtual Mock up for 3D Shop Drawing Review (Khemlani, 2011)

2.4.2/ 3D Coordination

Collaboration of the construction team with the architect, engineer and the owner is preferred to be started on early stages of design phase. At that time, the Building Information Modeling shall immediately be implemented. If the architect is only providing 2D drawings, then the construction manager should convert the 2D drawings to 3D intelligent models. When the specialty contractors, especially the mechanical, electrical, plumbing (MEP) contractors and the steel fabricators are involved, they need to spatially coordinate their work. The 3D coordination can be started right after the model is created to ensure that any same space interference (hard clash) or clearance clash (soft clash) conflicts are resolved.

Overall, the coordination efforts of construction manager and specialty contractors in advance of construction help to reduce design errors tremendously and to better understand ahead of time the work to be done.

2.4.3 Prefabrication

Prefabrication reduces field labor cost and time and increases accuracy in a good quality construction. There are more tools and options readily available in a controlled environment of the jobsite to perform work more precisely, and less costly in a shorter period of time. Prefabrication requires design and field accuracy. Building information models can provide this level accuracy by including the specifications, sequence, finishes, and the 3D visual for each component. However, the construction team must make sure that the BIM is interoperable with the software used by fabricators. This way the contractors can use the BIM and generate details for the product in their fabrication software. Once the details are approved, the products can be fabricated using Computer Numerical Control (CNC) machines. Furthermore, the construction managers must administer the procurement schedule of the products. Overall, the prefabricated products must be delivered to the jobsite on time.

Difficult steel connections generated in Building Information Model can be welded offsite. The welding of these small complex elements in advance of steel erection can save time and money. Furthermore, BIM helps to timely modify designs to eliminate or reduce use of beam penetrations that may result from mechanical, electrical, plumbing (MEP) conflicts. A few beam penetrations may become inevitable for complex project. A good coordination of these penetrations with BIM technology advocates determining the beam penetration locations and prefabricate offsite. Prefabricated beam penetrations would save tremendous time, money and effort in comparison to onsite beam penetrations. Moreover, roof penetrations for concrete rooftops should be sleeved prior to concrete pour at the roof level. Supplemental steel for each penetration may be required. These penetrations can be coordinated with BIM when the specialty contractors are on board (LeBlanc, 2010).

Curtain wall systems whether panelized or stick system, can be used with BIM to prefabricate parts and components. Panelized curtain wall systems may be considered for the schedule purposes. Stick systems require the use of assembly of each one of components onsite whereas the panelized systems already come prefabricated with all the components which include insulation, glazing, stone, framing, etc.

Walls, rooms, and houses can be virtually designed and constructed with Building Information Model. These walls, rooms and houses can be prefabricated with roughed mechanical, electrical, plumbing (MEP) components. Final MEP connections can be made once the prefabricated components are assembled onsite. In healthcare and biotechnology projects, various equipment such as Biosafety Cabinets (BSCs), fume hoods, autoclaves and cage washes, etc. may be required. This equipment’s may require some type of coordination with MEP contractors. For instance, fume hoods may come with prefabricated piping for vacuum, gas, or nitrogen lines at laboratories. BIM can be used to determine the exact location of the fume hood and more importantly, the drop in location to the prefabricated piping at the fume hood. This enables the in-wall roughing and plumbing drops of the piping work before the fume hoods come to the site. Moreover, the electrician can pull cables to junction box to later tie into the circuits for lights, outlets, and fan. Lastly, the ductwork contractor can use the information from the BIM to drop its branch duct so the fume hood can later be tied in. Overall, Building Information Modeling can help achieve the implementation of the MEP roughing work by promoting collaboration of information exchange between the subcontractors.

BIM can help to coordinate between casework installers and MEP contractors. For example, island benches (cores) are prefabricated with electric outlets, and gas turrets. BIM can be used to determine the roughing locations. Then, the electrical circuits of the island benches can be roughed to a junction box. The plumbing pipes can be fed to the horizontal branches above the ceiling. Overall, the roughing can be completed successfully with the use of Building Information Modeling process. Pipe manufacturer could use BIM to gather coordinated piping locations, lengths and sizes for its fabrication software as long as the interoperability is possible. This allows in-wall drops including hot, cold, drain/vent, vacuum, etc. to be prefabricated. The drops typically stick out a foot from the wall to provide connection to the horizontal branches above the ceiling. Furthermore, if pipes need to be weld, they must come at manageable sections. Welding small sections of black iron pipe with four inches or bigger diameter would be feasible to weld offsite whereas two 10 foot sections welded offsite would not be manageable. Also, offsets and joints would prefer to be prefabricated. Overall, it is ideal to prefabricate all the small pieces in a controlled environment with readily available equipment which would yield more efficient, higher quality, and less costly products (LeBlanc, 2010).

BIM can be used to enhance the information exchange of the products between participations. Furthermore, it is used to virtually coordinate the location and routing of the products. Based on this information, the products can be detailed using the fabrication software's. Once the material is prefabricated and arrives on site, the foreman of the specialty trade coordinates with the general superintendent to ensure that he is making the virtual design and construction a reality.

2.4.4 Construction Planning and Monitoring

The construction planning involves the scheduling and sequencing of the model to coordinate virtual construction in time and space. The schedule of the anticipated construction progress can be integrated to a virtual construction. The utilization of scheduling introduces time as the 4th dimension (4D). There are two common scheduling methods that can be used to create 4D Building Information Model. These are critical path method (CPM) and line of balance. In the Critical Path Method, each activity is listed, linked to another activity, and assigned durations. Interdependency of an activity is added as either predecessors or successors to another activity. Moreover, the duration of the activities are entered. Based on the dependency and duration of the activities, the longest path is defined as the most critical path. The activities defined in the longest path are defined as the critical activities. These activities do not have any float. In other words, if these activities are not completed within anticipated duration, the total duration of the project will be further pushed out. Overall CPM is a commonly used technique that helps projects stay within schedule.

Line of Balance technique uses location as the basis for scheduling. This method is an alternate to the CPM. It is advantageous for repetitive tasks to increase labor productivity. In this method, activity durations are based on the available crew size and the sequence of the location. Productivity of the labor force can be altered as needed to accurately depict the construction schedule. The approach focuses on the locations being completed by a trade before the other trade moves in. This reduces the number of mobilizations and resources. Overall, line of balance is a good scheduling method to plan and monitor repetitive tasks during construction progress. (Kenley, 2010)

The planning through using BIM enhances site utilization, space coordination, and product information. The model must include temporary components such as cranes, trucks, fencing etc. Traffic access routes for trucks, cranes, lifts, excavators, etc. need to be incorporated into the BIM as part of the logistics plan. Moreover, the site utilization consists of lay down areas, site work progress, and location of trailers and equipment and hoist assembly. Similarly, when the building is being closed in, the space coordination must be managed for the roughing and eventually finishing activities.

4D BIM can be used as a visualization tool to identify the safety features that will be required at different times. Based on these observations, the Temporary safety related structures such as rails and fences can be modeled in the BIM and the safety related activities can be integrated into the schedule. Once the model is used as a planning tool for safety, the 4D model can be used to monitor the safety precautions taken at the jobsite. Overall, 4D BIM can be used a proactive approach to enhance the planning and monitoring of the jobsite safety.

Construction managers must plan for coordination, shop drawings approval, fabrication, transportation, and installation times. They need to make sure the lead times for the material is accounted for so that it can have enough time to be installed or assembled. They can update this information on their 4D models. There are several field data acquisition systems that can be used with 4D BIM to keep track of the progress of .the construction. Radio Frequency Identification and 3D laser scanning Radio Frequency Identification (RFID) can be used to keep track of the material delivery status. The use of RFID is ideal for the prefabricated components of a project such as precast concrete panels. RFIDs can be linked into the BIM to show that the elements are in the correct location. For instance, a tagged projector can be linked to the element's type property in the BIM. The BIM and RFID integration helps to keep track of the location of the projector and indicate that the material is in the designed location once it is installed (Meadati, 2010).

RFIDs can alternatively be used to plan and monitor the workforce. They can be tagged to the hard hats of the trades to identify the manpower and the location of the workers for the day (Yazici, 2010). The daily activities of workman can be monitored closely to ensure that the manpower is adequate and that the labor activity is suffice to the planned 4D schedule. 3D Laser Scanning can be used to monitor the progress of designed Building Information Model. 3D laser scans and register point clouds of geospatial information which then can be processed to the designed Building Information Model. At that stage, the scanned as-built data can be manually checked against the original designed model to detect any deviations. However, there are no current algorithms to make this an automatic process. Overall, the 3D laser scanning technology can be a good quality control tool for new projects. For renovation projects with no 3D models, the laser scanning can be a good process to identify the current location and status of building components. The visualization can be helpful for space coordination in the renovation projects.

Construction managers can use BIM and the robotics total station technologies for accurate building practices. Site survey points generated in the Building Information Model can be uploaded to the robotic total station. Based on the points generated from the model, the field staff then can lay out all of the points. For instance, the accurate positioning of the hangers would ease the coordination of the MEP contractors. Furthermore, field staff can survey the components of the building with robotic total station to ensure that they are built per designed model within acceptable tolerance range. This proactive quality control approach would prevent any subsequent conflicts. Overall, robotic total station uses the information from BIM to survey both for construction and quality control purposes.

Planning and monitoring is an extremely important part of the construction. The construction manager can use various 4D BIM enabled tools to enhance the quality control process. Overall, construction planning and monitoring with 4D BIM is a great process to build a facility per the designed model.

2.4.5 Cost Estimation

The two main elements of a cost estimate are quantity take-off and pricing. Quantities from a Building Information Model can be extracted to a cost database or an excel file. However, pricing cannot be attained from the model. Cost estimating requires the expertise of the cost estimator to analyze the components of a material and how they get installed. If the pricing for a certain activity is not available in the database, cost estimator may need a further breakdown of the element for more accurate pricing. For instance, if a concrete pour activity is taking place, the model may account for the level of detail for the rebar, wire mesh, pour stop, formwork, concrete etc., but not include it as part of the quantity take-off extraction. Cost estimator may need this level of detail from the model to figure out the unit price which consists of the unit material cost, unit labor cost, overhead and profit. The unit labor cost is driven by the mobilization and installation durations, and the labor wage while the unit material cost is the sum of the material costs used for the activity per unit. Once the unit price is attained, the cost of the entire activity can be attained by multiplication of the total quantity extracted from BIM and unit price.

In Building Information Model, the data output is as good as the data input. It is significantly important to have the constructor and the designer to agree on component definitions. For instance, if an architect is using concrete slab to show the roof for modeling purposes, the roof quantity information will not be accurately accounted for quantity extraction purposes in the model. Overall, the BIM technology is a great tool to optimize the productivity of the estimators through quantity extraction from the model especially if the construction and design team work collaboratively.

2.4.6 Record Model

Construction Managers can provide a record Building Information Model to the owner at the end of a project. The model includes the integration of the as- built from the subcontractors. Furthermore, each object property in the model can also include links to submittals, operations and maintenance, and warranty information. Centralized database can help the facilities department to find information easier. Record model can be used to manage security and safety information such as emergency lighting, emergency power, outlet, fire extinguishers, fire alarm, smoke detector and sprinkler systems (Liu, 2010).

Furthermore, the facility team can analyze energy efficiency of a virtually built model. In addition to that, facilities team can plan with record model to maintain and renovate buildings by tracking spatial information such as furniture, equipment, and MEP (mechanical, electrical, and plumbing) connections. Finally, the facilities department can use the model to generate cost and schedule impacts for maintenance and renovation projects. Overall, a record model can be utilized to optimize facility management and maintenance.

Generation of Building Information Model as a record model is an area in the process of development. The interoperability of the record model with various applications could potentially be a challenge. Furthermore, the owner needs to be willing to allocate funding to train employees, update and maintain the record Building Information Model (Keegan, 2010). As the benefits of the record model are realized, the owners will be more demanding of the record Building Information Model. An accurate record model that contains the scope of the project and the needs of the facilities department can help the owner manage and maintain the building tremendously. This can leave a long lasting positive impression of the construction manager to the owner of the project.

2.5 PROJECT DELIVERY METHODS & BIM FOR CONSTRUCTION MANAGERS

Traditional Design-Bid-Build, Construction Management at Risk, Design/Build and Integrated Project Delivery methods are the most common project delivery approaches that the industry currently practices. No matter which delivery approach is chosen, the general contractor or the construction manager can use BIM. Construction managers or general contractors can use BIM to extract quantities of work to prepare cost estimates. Furthermore, they can provide powerful 3D renderings. Moreover, schedule integrated BIM known as 4D BIM can be used for animations, safety analysis, and to prepare site logistic plans. Construction managers can use BIM to coordinate work with subcontractors. They can also update schedule and costs with BIM. Lastly, they can turn over an as-built building information model to the owner’s maintenance team.

The construction manager job is officially started in a project as soon as is awarded. The project award timeline to the construction manager and the organizational structure of the project are dependent upon the construction delivery approach. These two factors impact the involvement of the construction managers in the Building Information Modeling process.

In the traditional approach, the design, bid, and build phases follow each other. The architect, typically the lead designer in building projects and construction manager works directly for the owner. The engineering consultants are part of the designer's team. The engineer and the architect first design the building. Upon, the completion of the design phase, the construction manager's also known as general contractors in the traditional approach bid for the job. Once the bid is awarded, then the construction starts. It is not a fast track project delivery method. In other words, the approach does not involve early participation of the construction team during design. If the designers generated a 3D parametric model for the project, the BIM will lack the knowledge of the contractors during the design phase. Overall, Design-Bid-Build eliminates the benefits of having the construction input during design phase when the ability to influence the cost is the highest as shown in figure 1. The architects and the engineers may not want to share their models due to risks, liability concerns, unauthorized reuse of intellectual properties and misinterpretation of the information included in the model.

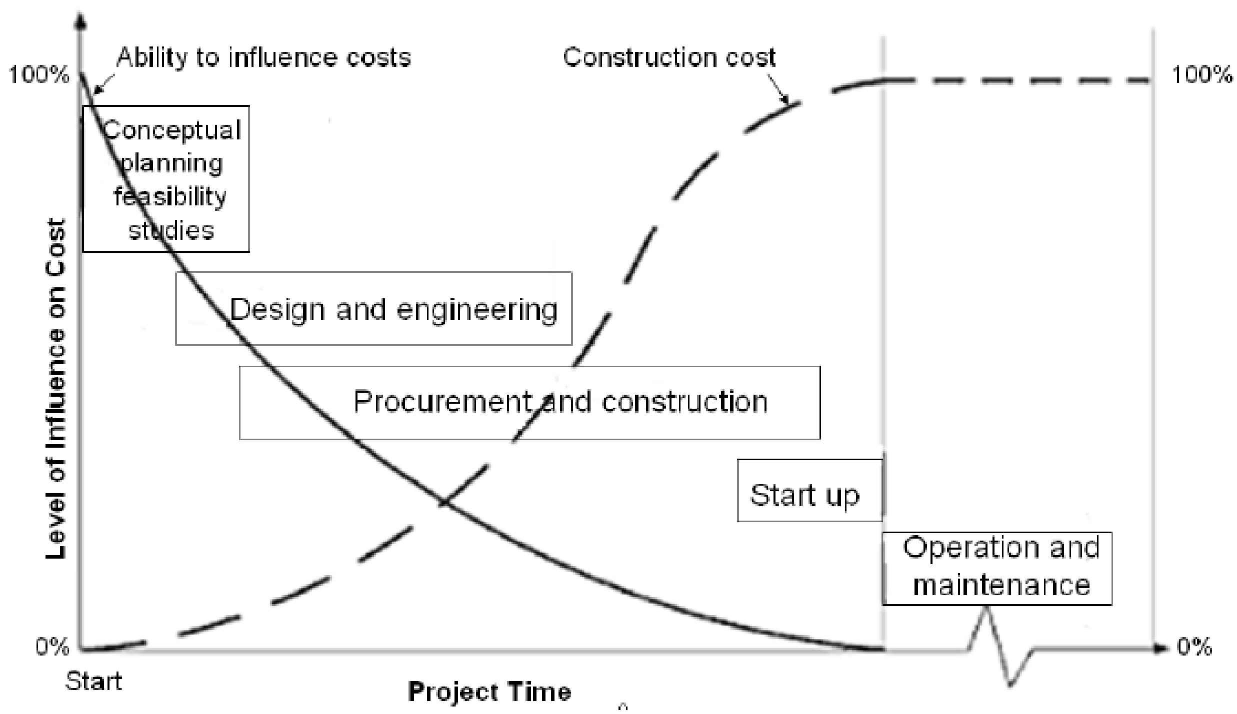

Figure 2: Project Life Cycle - ability to influence cost (Eastman, 2008)

In Construction Management at Risk delivery method, both the designer and the construction manager work directly for the owner. They can collaborate and complement each other's work and report to the owner. When BIM is used, this approach carries the risk like the traditional method that the architects and the engineers may not want to share their models due to risks such as liability concerns, and unauthorized reuse of intellectual properties. Also, Construction Management at Risk approach usually entails the preconstruction services. This enables the input of the construction team to the Building Information Model early on during the design phase. It can be used for private and public fast track projects.

Design/Build delivery approach requires a single entity to take over the responsibilities of the designer and the builder for the owner. Selection of Design/Build professionals is usually based on a combination of cost and professional qualifications. Since the designer and the general contractor work together, quality control assurance is limited. In other words, cost could become a priority over quality. On the other hand, Building Information Model can be used freely right from beginning of the project. The intimate collaboration of the designer and the builder can yield to using the Building Information Modeling as a strong and effective process.

Finally, a new method known as integrated project delivery (IPD) contractually requires designers, construction manager, subcontractors and owners to share the project risks. If the project stays within budget, then all the project participants receive their share of profits. Otherwise, they all lose their fee. This incentive promotes all the participants to work together towards a common goal. They share all the Building Information Model, share decision making, and share the responsibility. This joint project management approach results in pure collaboration and no litigation. Overall, Building Information Modeling makes IPD achievable. (Handler, 2010) The Building Information Modeling is a process of computer-generated design and construction of the project. The traditional approach will not be the best approach to encourage the benefits of BIM since the construction manager or the general contractor will not be involved in the process until after the design phase of the project is complete. Therefore, Construction Management at Risk, Design/Build, and Integrated Project Deliveries (IPD) are better project deliveries to collaborate and to maximize the use of BIM. This would enable the construction managers to provide input by collaborating through BIM during the design phase when the ability to influence the cost and schedule is maximized.

While these traditional methods are still very much in use, there has been a strong movement toward more streamlined processes to reduce construction times and enhance collaboration of team members. The Design-Build delivery method is one example of this streamlining. By taking the competitive bid phase out of the middle of the delivery process and placing the entire design contract under the scope of the general contractor, there is no longer a procedural or contractual separation between the design and construction of the project. The owner only has to carry one contract for both design and construction services. This allows for the construction to begin well in advance of the completion of all design documentation as the design documentation is produced in concert with the construction almost on an as-needed basis.

While the Design-Build methodology is perhaps more efficient than Design-Bid-Build, these "traditional" methods both share some fundamental flaws which the newest delivery method, Integrated Project Delivery (IPD), is capable of eliminating.

Because IPD is so new there is no official definition, however the California chapter of the AIA offers this working definition:

Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction. Integrated Project Delivery principles can be applied to a variety of contractual arrangements and Integrated Project Delivery teams will usually include members well beyond the basic triad of owner, architect and contractor. At a minimum, though, an Integrated Project includes tight collaboration between the owner, the architect, and the general contractor ultimately responsible for construction of the project, from early design through project handover.

While IPD is seen as the possible future of project delivery that is being fueled by BIM, it is still the exception and not the rule. Before IPD becomes commonplace on all projects, a transitional period will ensue during which delivery requirements will begin to change as well as the relationships and expectations of the owner, designer, integrator and manufacturer.

Owners will become more involved in all aspects of the project simply because the model will provide them immediate and vast information. Rather than having to try to interpret a stack of 2D plans, owners now have access to enormous amount of information which can be formatted to meet their needs. This includes virtual walkthroughs, detailed equipment lists and accurate cost estimates.

BIM allows for the building to be built in a virtual environment before being actually built. With this change, designers will become more involved in decisions which might previously have been considered "means and methods" and left to the contractor to figure out during the installation. Some examples include more detailed routing of infrastructure and placing devices in their exact location.

BIM acts as a central database for the project and as such it is regularly evolving. Due to this constant state of flux, expectations must be set and agreed to among team members regarding the expected level of completion at various points during the project. Most projects consist of multiple models which are linked together. These models are typically exchanged between team members on a regular schedule whether it be weekly or daily. These exchanges are independent of the major scheduled deliverables of the project such as 50% Design Development or 90% Construction Documents. When these models are shared, they are usually not in a completed state; therefore, there must be an understanding between parties about the level of completion and coordination expected for model exchanges between the deliverables established by contract.

The entire project team will have increased communication and will begin to work as one entity rather than separate team members who only exchange documents at predetermined milestones. The model will become a consolidated design document which evolves on a constant basis during design, through construction and into the management of the facility. This consolidation requires a tighter and more constant information exchange which sometimes takes place via co-locating of team members either physically or virtually.

In contrast to traditional CAD-based design, BIM is a front-loaded process with substantial benefits reaped toward the end of the process which consist of manipulation of the database's data points. It should be noted that this requires substantial effort up front to not only put information into the database but to also collect more data from the very start. If the data is not available at a given time, there should be an effort made to analyze what data might or will be required so that the correct mark hole can be created in the database from the very beginning. The model is only as good as the data set that goes in.

Traditional delivery methods invoke inefficiencies because participants are contractually placed into silos of scope. These silos have a two-fold detriment to the efficiency of a project. First, when any knowledge needs to transfer from one team member to another, such as from the design team to the contractor, there is inefficiency created when the contractor has to take the time to get up to speed on the design documents to be able to move forward with the scope of work. Secondly, a team member's success is only tied to the success of the individual silo rather than the overall success of the project.

Despite the delivery method, BIM Addendum created by Consensus can be integrated as an additional rider to each project participant's contract. BIM Addendum does not impact the contractual relationships of the project participants. However, it requires the participants to communicate, collaborate and exchange information via using BIM tools. BIM requires the implementation of BIM Execution Plan which identifies the BIM needs of the project. It consists of checklist of issues including but not limited to: the type of Models to be created, required level of detail, purpose of each model, responsible party for creation of each model, schedule for delivery of Model, file formatting, file naming, object naming, interoperability of BIM tools, coordination and clash detection, and BIM website utilization, etc (Lowe 2009).

In the BIM addendum, Design Model and Construction Model are identified. Design Model developed by engineers and architect is expected to be completed at level of detail of two dimensional construction documents. Construction model developed by the contractor and subcontractor is equivalent to modeling of shop drawings and related information. Developer of each distinct model can work and update his or her own files and are responsible for dimensional accuracy of model. Distinct models can be linked to each other to form a federated model. The federated model can be used for many purposes including clash detection, marketing and facility maintenance purposes (Lowe 2009).

As part of BIM Addendum, parties waive claims against each other. BIM Addendum addresses the risk of the potential intellectual property infringement claims. Each party allows the use of their models for the benefit of the project. If a software failure is found to impact the project, the owner is mainly taking the risk and the schedule extension for the project is allowed (Lowe 2009).

2.6 CONSIDERATIONS AND LIMITATIONS OF BIM

BIM has the potential to improve the communication and coordination between the different stakeholders of a project. BIM's benefits range from simple improvements in efficiency and coordination to greater client satisfaction with all of the perceived benefits of BIM, AV professionals should also be aware that there are a number of considerations and current limitations that must be taken into account.

Cost of Software and Hardware

Every organization currently utilizing 2D or 3D CAD drafting software can attribute a cost element against purchasing, maintaining and upgrading software licenses to keep a competitive market advantage. Current trends show that the cost of BIM software packages tends to be more expensive than CAD software packages available on the market.

With the introduction of BIM software, the requirements on hardware have increased significantly. Currently, CAD software can be operated (with limitations) on a vast majority of professional laptops. Yet with the introduction of BIM software, dedicated high-specification workstations, equivalent to those required by advanced modeling and rendering software, are required.

Software and program requirements are ahead of hardware availability. With BIM software, it is essential to know exactly what parameters of the hardware improve performance and what elements have no major effect at all.

More details on the hardware requirements for BIM software may be found in the Getting Started section.

Cost of Training

With new software, there is a great demand to train staff quickly so that the investment can be justified. It is not realistic to assume professionals with CAD proficiency will be able to learn new BIM software quickly or without specialized training. Given the fundamental differences between BIM and CAD, training should be considered a requirement for all professionals involved with designing and producing documentation.

BIM provides the ability for every member of the team to be involved in the design and modeling process, giving them complete control of the end product. Investment in training for early adopters provides them a competitive edge with projects that have clearly specified requirements to be documented utilizing BIM.

Transition from Drafting to Modeling

When moving from a CAD-based drafting environment to a BIM-based modeling environment, a change in the workflow will surround what used to be simple drafting tasks such as copying markups or picking up redlines. These tasks now require a higher-level skilled design drafter who has an understanding of the project and the materials used. The costs associated with training and maintaining a skilled design modeler are higher than a draftsman with no knowledge of the trade. Some companies may even be compelled to stay out of the BIM world altogether due to the time- and knowledge-intensive nature of BIM.

The transition from traditional CAD will also place an increased level of responsibility on the designer to ensure that all system components are coordinated with the other design professionals such as architecture and engineering services and that site issues are reduced to a minimum. Companies have a few different business models to consider when thinking about staff training with respect to BIM.

..The first option involves the training of current designers to undertake all of their design work in the BIM environment.

..The second involves up-skilling all of their drafting staff to a higher technical level to undertake design responsibilities.

..The third is a combination of the first two where there is a specific set of rules and guidelines for mark-ups so that design mark-ups can be translated into the model clearly and efficiently.

In any case, the BIM process allows for coordinated delivery earlier in the design process so that potential double handling or redesign is avoided. This benefit outweighs the cost of any additional training to up-skill staff no matter what business model for the delivery of BIM projects.

Compatibility between Software Platforms

One of the biggest issues with early adaptors of BIM is the issue of inter-product compatibility. Due to the relatively new nature of the market, every software manufacturer is doing something different with its software. This interoperability challenge can make it difficult for projects to function if different team members own different software packages.

This interoperability issue is not limited to different software platforms; due to the rapid development of the BIM software industry newer versions of programs within the same platform can have interoperability issues.

One alternative to the current product-specific models is a vendor-independent, neutral-file format. One such file format is the Industry Foundation Classes (IFC) format which captures both geometry and properties of intelligent building objects (objects with associated usable metadata) and their relationships within Building Information Models, thus facilitating the sharing of information across otherwise incompatible applications.

2.7 Experience Of BIM Implementation In Other Countries

2.7.1 BIM implementation in Finland

A. Public Sector and BIM Guidelines

Senate Properties is the public owner running pilot projects using BIM and *Industry Foundation Classes (*IFC). There has been a growing interest by (Architectural Engineering and Construction/Facilities Management) AEC/FM companies in BIM and IFC compatibility. Their focus is to use product model technology in ordinary project work. In Finland, the BIM guidelines are being drafted as a result of the Pro IT project which is an R&D project conducted with industry wide support. It developed a number of guidelines on product modeling. The guidelines are in Finnish language and cover general principles of product modeling in construction projects, product modeling in architectural design, product modeling in structural design and product modeling in building services design (Senate Properties, 2009). These guidelines describe product modeling in details, however, these guidelines do not explain in details the data exchange specifications which could be the next step for further development in the guidelines.
(Wong, A.K.D., Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries)

B. Private Sector and BIM Research

There are numerous private sector companies in Finland doing R&D and promoting BIM and higher utilization of BIM in Finland than in the other Scandinavian countries. The Association of Finnish Contractors is also active in promoting implementation of BIM in the industry, along with the state client (Senate Properties) whose path is similar with the addition of the need for open standards.

Research organizations and universities in Finland are running several programmers involving the implementation of BIM. It would make it possible to use the information generated in the design phase to be used during the building operation phase. (Wong, A.K.D., Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries.)

2.7.2 BIM implementation in Norway

A. Public Sector & BIM Guidelines

In Norway, the civil state client Statsbygg has promoted the use of BIM, as well as the Norwegian Homebuilders Association. Norway’s BIM guidelines are called BIM manual. These guidelines are based on the experiences from the Statsbygg’s HIBO project. The BIM manual is delimited to the Norwegian standard NS8353 CAD manual, and it is prepared in coordination with the NBIMS standard in the USA. This manual was actually for Statsbygg’s use however it is now also being used by other parties in Norway as well (Wong, A.K.D) and Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries)

B. Private Sector & BIM Research

In private sector Selvaag-Bluethink is developing BIM and ICT solutions based on BIM. SINTEF in Norway is the leading organization conducting research in BIM. It is a part of Erabuild which is a network of national R&D programmers, focusing on sustainable tools to improve construction and operation of buildings. From Norway, the Research Council is the funding organization for Erabuild. Norway is among the first few countries to develop IFD (International Framework for Dictionaries) standard in the building construction regime (i.e. ISO 12006-3) which is an initiative for global application. About 22% of the AEC/FM companies in Norway have used or implemented BIM or IFC enabled BIM. SINTEF is also working on several internal and cross-department projects under building SMART initiative besides developing BIM Guidelines. Building SMART is a national coordinating effort to focus and collaborate on all building development and implementation projects. Under Norwegian University of Science and Technology (NTNU), several student projects and thesis proposals are focused on building SMART technology and are being conducted in collaboration with industry and research organizations to develop student courses. Norwegian IAI Forum is developing the definitions of the requirements the aim of the IDM is to support the information exchange requirements for business processes within the building construction industry. Through IDM, the parts of the IFC model that is necessary for information exchange between identified processes can be specified. (Wong, A.K.D., Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries.)

2.7.3 BIM implementation in Denmark

According to a survey which was carried out in 2006 (cited in Kiviniemi et al., 2008), the most commonly used BIM application among architects was Architectural Desktop with approximately 35% of the firms using it. It was followed by Archicad, Revit and Bentley Architecture.

Denmark has slight edge on other Scandinavian countries in prescribing by specific modeling standards/guidelines in their construction works by the clients. These requirements have already been stated by the government and some of them are part of the law.

A. Public Sector and BIM Guidelines:

In Demark, there are at least three public owners who have initiated the work on BIM. These include The Palaces and Properties Agency, The Danish University and Property Agency and Defense Construction Service. In Denmark, although the governmental projects do not represent a large part of the total property area, their impact on the market created by the IFC requirements is big. Denmark has actively put forth its requirements for using BIM in the governmental projects. Such requirements from the government are known as By (Det Digital Byggeri, 2007). The architects, designers and contractors participating in governmental construction projects have to utilize a number of new digital routines, methods and tools starting from January 2007. The initiative is called ‘Det Digital Byggeri’ in Danish which means ‘the Digital Construction’. Since the initiative is still under experimentation, the governmental clients have exercised flexibility in its use. The use of 3D models in the projects has been related with the price of the project. For projects above 5.5 million Euros, 3D models in the design have to fulfill a number of requirements regarding content, information levels for the various phases, which are to be defined by the client for individual project. The models are recommended to be exchanged using the IFC format. Also there are a few municipalities and private clients in Denmark who demand for object based modeling. This was accomplished under the Digital Construction program initiated by the Danish Enterprise and Construction Authority. A package of guidelines regarding 3D was developed. The guidelines concerned both the setting up and fulfilling requirements in file and database based CAD/BIM applications. These guidelines are also available in English which include: 3D CAD Manual 2006, 3D Working Method, 3D Working Methods and Layer and Object Structures 2006. (Wong, A.K.D., Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries)

B. Private Sector and BIM Research:

In the private sector ‘bips’ is developing BIM guidelines and Ram boll working for collaboration between Ramey and IFC. ‘Bips’ has adopted the results from the Digital Construction project and are promoting the new working methods to all companies in the Danish Construction Industry. Ram boll is the main organization in Denmark performing research in BIM. Danish Enterprise and Construction Authority is an organization supporting the research in BIM in Denmark. Other organizations and universities are also performing R&D work in BIM. (Wong, A.K.D., Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries.)

2.7.4 The United States of America

There are three forces changing the capital facilities industry today: Productivity decline, advancing technology and lifecycle perspective. Research and development efforts are occurring in various organizations to understand who needs what information, when, and how will it be exchanged within and across business organizations. A few of the many efforts underway include:

The Open Geospatial Consortium (OGC), an international organization that is developing publicly available interface specifications to support interoperable solutions that “geo-enable” data used in the Web, GIS and BIM.

The Construction Operations Building Information Exchange (COBIE) is working to capture and exchange building information relevant to facility managers. The Open Standards Consortium for Real Estate (OSCRE) focuses on data exchange within the real estate business process.

The International Code Council (ICC) is developing data and rule definitions to automate code compliance checking. The Association of General Contractors (AGC) continues its development of exchange specifications for transactional data now commonly exchanged as paper documents, such as agreements, change orders, and submittals.

The primary organization working on interoperability is building SMART International (formerly the International Alliance for Interoperability) with 13 chapters worldwide. It is a non-profit alliance of building industry participants including: architects, engineers, contractors, building owners and facility managers, building project manufacturers, software vendors, information providers, government agencies, research labs and universities. Its goal is to develop a universal standard for information sharing and interoperability of intelligent digital building models. Their major product is the IFC. In the US, building SMART is organized under the National Institute of Building Sciences.

There is a number of exchange formats used today to achieve varying degrees of interoperability. *Proprietary file exchange* formats such as DXF, and DWG have been successfully used in the past to exchange geometric and alphanumeric data. *Proprietary direct links*, which are custom programs that use the application program interface (API) language of the host program, can be very robust and often seamless to the user. There are also a number of *Open Standard formats*. Extensible Markup Language, XML, is an open standard for transfer of alphanumeric data. Though the standard is open the applications are written by software companies or organizations.

Industry Foundation Class (IFC) is another open standard exchange format. It is the only format that can exchange 3D geometric object properties, organizational relations, object attributes, alphanumeric, and other BIM data. (CIS/2 is a similar open standard focused on structural model exchange) IFC data model is the only broad based object model exchange method and will likely become the international standard for building data exchange within the construction industry (The State of Wisconsin Department of Administration, 2009).

A. Public Sector and BIM Guidelines

On July 1, 2009, Wisconsin became the first state to require the use of BIM on public projects. The BIM requirement applies to then performance of A/E services under a design-bid-build delivery system on any large construction project, defined as those projects with a total funding of at least $5 million, or any new construction with at least $2.5 million in funding. BIM use is encouraged, but not required on all other projects. Wisconsin also issued its BIM Standard and Guidelines document to facilitate the implementation of BIM on applicable projects. One month later on August 12, 2009, the Texas Facilities Commission (“TFC”) announced that it was requiring the use of BIM on all public design and construction projects. Like Wisconsin, the TFC (through its Facilities Design and Construction division) had been studying the use and impact of BIM and developed a set of BIM standards and guidelines and an interoperable BIM template to facilitate and standardize BIM implementation. The Texas announcement went even further than its northern counterparts by eliminating the minimum threshold project value for the use of BIM. This requirement will extend to all real estate development (including the state university systems) for the state of Texas.

The General Service Administration (GSA) Public Buildings Service (PBS) Office of the Chief Architect (OCA) established the National 3D-4D BIM Program in 2003 (Kam 2007). The primary goal of the program is to phase in 3D, 4D, and BIM adoption for all major projects. Additionally, the GSA hopes to create a knowledge portal community and a six-part BIM Guide Series. Currently, Series 01 and 02 are available online in draft version with Series 03-06 in various unpublished stages. Another large owner implementing BIM is the U.S.

The National Building Information Model Standard (NBIMS) serves as doctrine for all the key members and roles of the facility lifecycle to agree on the strategic level of BIM implementation. Within the NBIMS are other resources that address operational and tactical level concerns. Operationally, these would include references to documents like the GSA BIM handbooks, the USACE BIM Road Map, or the AGC's Contractor's Guide to BIM. Tactically, items like the Interactive Capability Maturity Model (I-CMM) are meant to evaluate individual BIMs' ability to create, leverage, and share information. In this way, the NBIMS answers questions about all levels of BIM. (The State of Wisconsin Department of Administration, 2009). NBIMS establishes standard definitions for building information exchanges to support critical business contexts using standard semantics. Implemented in software, the Standard will form the basis for the accurate and efficient communication and commerce that are needed by the building industry and essential to industry transformations. Among other benefits, the Standard will help all participants in facilities-related processes achieve more reliable outcomes from commercial agreements. The National Building Information Modeling Standard (NBIMS) Committee is a committee of the National Institute of Building Sciences (NIBS) Facility Information Council (FIC). The vision for NBIMS is "an improved planning, design, construction, operation, and maintenance process using a standardized machine-readable information model for each facility, new or old, which contains all appropriate information, created or gathered about that facility in a format useable by all throughout its lifecycle." The organization, philosophies, policies, plans, and working methods that comprise the NBIMS Initiative and the products of the Committee will be the National BIM Standard (NBIM Standard), which includes classifications, guides, recommended practices, and specifications. (National Institute of Building Sciences, 2007.National Building Information Modeling Standard. Version 1- Part 1: Overview, Principles, and Methodologies.)

2.7.5 Summary of these countries to implement BIM

The countries summarized within this chapter include the following, Finland, Denmark, Norway and the United States of America. In all of these countries the public sector has played a major role in the implementation of Building Information Modeling. These include State departments as well as public institutions. Guidelines have also been set up in each of these countries to assist with the uniform implementation across the industry, and in line with the implementation in other countries. In Finland public sector involvement has been of great importance, and BIM guidelines are being drafted as a result of the ProIT project which is an R&D project conducted with industry wide support.

The public sector has also played a large role in the implementation of BIM, putting Finland ahead of most other Scandinavian countries in terms of utilization of BIM in Finland. In Norway two companies have played a major role in the public sector implementation of BIM, namely Statsbygg and the Norwegian Homebuilders Association. The guidelines for BIM developed in Norway are called BIM manual. These guidelines are based on the experiences from the Statsbygg's HIBO project, and are prepared in coordination with the NBIMS standard in the USA. In the Norwegian public sector about 22 percent of AEC/FM companies are implementing BIM.

The public sector has also been involved with setting up guidelines for the use of BIM and is one of the first few countries to develop IFD (International Framework for Dictionaries) standard.

It is also working on several internal and cross-department projects under building SMART initiative besides developing BIM Guidelines.

In Denmark the public sector has a big influence on the market, and at least major public owners have adopted the use of BIM in their projects. Denmark has actively put forth its requirements for using BIM in the governmental projects.

In the United States the primary organization working on interoperability is building SMART International. Its goal is to develop a universal standard for information sharing and interoperability of intelligent digital building models. Their major product is the IFC. In the US, building SMART is organized under the National Institute of Building Sciences. Wisconsin became the first state to require the use of BIM von public projects, with Texas being the second State to require the implementation of BIM by the Texas Facilities Commission on public design and construction projects. Another large owner implementing BIM is the U.S. Army Corps of Engineers (USACE.).

The assistance of the public sector in the implementation of Building Information Modeling is of great importance. This is can be seen in all of the countries analyzed above. Private sector has also made a large Contribution to the implementation of BIM, and a cooperative effort is required between public and private companies to establish guidelines for the implementation of BIM in industry.

CHAPTER THREE

3. BIM IMPLEMENTATION

3.1 KEY STEPS TO SUCCESSFUL BIM IMPLEMENTATION

BIM implementation requires proper planning, patience and full commitment from all levels of the organization. When introducing BIM to an organization, proceeding with only a minimum amount of knowledge is a common mistake and can be costly.

3.1.1 Develop a BIM Action Plan

Developing a solid BIM action plan should be the first step toward getting your organization up and running in a BIM environment. Without this plan in place it is easy to lose track of what information is required to be successful. The plan should consist of two major sections: analysis and implementation.

Analysis:

A majority of the plan should be focused on information gathering about current methods, procedures and business strategy. The transition to a BIM workflow is a major shift for any organization on all levels; as such, it is an excellent time to look deep into your workflow to find any inefficiency that can be fixed. The analysis portion of a BIM action plan should include:

Existing Processes Identification and Analysis

It is important to conduct a detailed analysis of existing internal and external business processes to help establish a base line for where to start to achieve the goals established later in the plan. This analysis should include a detailed review of how projects are currently being processed through the organization from initial marketing through completion.

Technology Analysis

A detailed technology analysis identifies existing hardware and software technologies and their associated costs utilized by the organization. A review of current document and data management should also be included in the analysis.

Personnel Analysis

A detailed review of personnel should be conducted to help establish a few key pieces of information by providing answers to the following:

- What are the current roles of your project teams?
- Who will need to be trained with the new software?
- What level of training will each type of employee require?
- How will the new requirements of a BIM-based project modify the current make-up of your teams?
- Do you still require pure drafters?

- Can your current drafters become junior-level designers?

Cost Analysis

The transition from a CAD-based organization to a BIM-based organization carries a significant cost impact on three major fronts:

Hardware: Current BIM software requires a higher-performance workstation when compared to CAD software on a comparable-sized project. This BIM implementation may require a significant upgrade of current systems to ensure efficient workflow.

Software: BIM software will need to be purchased. The best resource for information regarding the best version of software and support to purchase are the many resellers out there. With resellers you can discuss the details of your needs and business plan to help identify the correct route to take – whether it is a single license or a full blown subscription with technical support.

Personnel: Educating and training employees to use BIM software and the new associated delivery processes costs money. This cost will most directly be related to training but there will also be a temporary loss of productivity while existing processes are transitioned to a new methodology.

Once the above-mentioned analyses have taken place, the next step is to develop an overall phased strategy for implementation. The implementation should include:

Timeline

A detailed timeline is required to ensure that the overall strategy is being implemented in a timely and organized process.

Personnel Changes

A change to a BIM delivery process represents a big change to an existing CAD workflow and thus a change to individual employee roles. The biggest change is a move away from pure drafters. With the BIM process focused around building a project in the virtual environment, those who are interacting with the model require more trade knowledge to be efficient.

Generally speaking, two new roles will be defined within the organization: a company BIM manager and project BIM managers. A company BIM manager will lead the charge for the company and be the guiding force behind implementation, standards development and software decisions. On each project, a project BIM manager should be assigned who is responsible for project-related BIM decisions, interacting with other project team members, BIM managers and maintenance of the model.

Training Plan

Training on a BIM platform is best completed using a “Just in Time” method. A lot of the concepts involved with BIM are very different when compared with a traditional CAD workflow and therefore are best learned working on an actual project. A proven method of success is to have multiple training days consisting of half a day for classroom instruction followed by half a day of actual project work with the instructor available for hands-on teaching. Training should start with only a small group of employees on a single project so that they can help streamline the BIM workflow prior to getting the entire organization up to speed.It is also advantageous for at least a single employee to receive in-depth training and then act as the BIM manager for the company. This person can then be the “go-to person” for help and can lead the establishment of standards.

Keys to Success

Successful BIM implementation within a company starts with the shared vision of change and buy-in from all members of the organization. Senior leadership needs to support the change and be willing to sacrifice a little in the beginning to reap the future rewards.

Other organizations are at all stages of the BIM implementation process - from thinking about it, starting to implement and fully operating in a BIM workflow. Additionally, there are many local and regional BIM and IPD groups that meet on a regular basis to discuss BIM-related topics. It is important to network with industry peers to share successes and failures to help better the industry as a whole.

The key to success in any BIM project is collaborative effort among all team members, which includes but is not limited to the project owner, the design team, general contractor, subcontractors and vendors/suppliers. Information data must flow freely between all of the BIM project team members to obtain maximum advantages in a BIM project. The project owner plays a central role in leading the discussion and decision-making process when it comes to applying BIM to his/her project.

Use available BIM resources to further understand of more advanced BIM concepts and practice. Set aside enough resources to ensure that your organization is not just buying software but is engaging in a business process that will meet your current and future business needs and opportunities.

With an intelligent implementation of BIM technology, your team starts to develop skills and techniques, build confidence in the software and pace the future work for potential benefits. For your organization it will mean new opportunities to provide the highest level of product.

3.1.2 Hinders of BIM implementation

Although the BIM process enables several benefits, for all actors as well as at all phases of construction, there are several issues that need to be addressed or fixed in order to gain a smooth implementation, so that these benefits can be realized. Some of these are quite simple to remove were as others could be considered impossible to even mitigate. Some of the issues can be grouped into the following four categories: (Arayici et al., 2005)

- Legal issues.
- Cultural issues.
- Technological issues.
- Fragmented nature.

These categories do not contain all issues, but they contain several of those who have a major impact on the BIM implementation, following is a brief description of some issues that an organization needs to address in their effort of BIM implementation.

3.1.3 Legal issues

The BIM model is the result of a collaborative process and several actors have been involved in the making of the model, issues has risen when it comes to ownership of the model and especially bound to who is responsible if something in the model is incorrect (Sabo and Zahn, 2008).

The question of who owns the model is an argument between the consults and the client. The consult might want to own the rights to the model in order to protect the information about special solutions as well as be able to reproduce similar solutions to other projects. The client consider ownership of the model important in order to use it as a tool for facility management, be able to reuse parts of the model with another consult, and be able to include it in the handover if the building changes owner.

The responsibility issues is due to that several actors are able to adjust the model and that means revealing unfinished work, this gives uncertainties from the actors regarding the accuracy of the BIM model (WSP Group, 2011 & Gu and London, 2010). This uncertainty can be revealed in that some BIM projects uses BIM in the design phase but before handing over to the constructor, they transform the 3D drawing to 2D.

3.1.4 Cultural issues

The construction industry is known for their conflicts regarding change and mistakes, which often go all the way to court (WSP Group, 2011). This fosters a culture that is heavily influenced by traditions where people like to do things the way they have worked before. This can be seen in that the business often tries to re-implement their traditional manual process with IT support (Arayici et al., 2005), instead of looking at how IT systems can improve their processes.

“Businesses need to identify the practices that belong to the old system and accept that they are not God-given eternal truths, but stem from a certain technological base – one that is evaporating.” (WSP Group, 2011). **CHALMERS**, *Civil and Environmental Engineering*, Master’s Thesis 2012:21 13

3.1.5 Technological issues

The most discussed issue when it comes to the technological aspect is the interoperability between the different programs. Another concern were technological issues have risen is regarding security. The interoperability issue is about that different software manufactures uses their own standards, which are not compatible with each other, this inhibit the actors to use one single program for all their projects. The interoperability issue and lack of standard also hinder efficient use of third party programs, these programs often have trouble in extracting data automatically from the model, thus demanding more manual work and increasing the risk for mistakes.

The security aspect concerns break-in and copyright breaches, and the risk for malicious software reaching the server. The worst case scenario with malicious software would be that the entire model gets erased or that someone goes in and changes parameters in the model so that the drawings handed to the contractor results in a wrongfully constructed building.

3.1.6 Fragmented nature

The designers, developers, contractors and construction managers all tend to focus on their area and protect their interests in the building process, giving a fragmented industry (Johnson and Laepple, 2003). Another issue is that the industry consists of many small companies which have trouble to afford the high initial investment needed for training and software purchase that are required to offer BIM services. BIM is increasingly used as an emerging technology to assist in conceiving, designing, constructing and operating the buildings in many countries, notably in the United States. Other countries including Finland, Singapore, Denmark, and Norway have also adopted BIM at the public and private sectors. Various methods of implementing BIM have been used in different countries. These different models adopted by public and private sector companies and organizations and this section aims at looking at the some of these models. The implementation of BIM depends on the size and the nature of the economy at hand. These factors are important when trying to introduce BIM in an economy.

CHAPTER FOUR

4. BIM IN ETHIOPIA AND ANALYSIS DISCUSSION

4.1 BIM IN ETHIOPIA

Since 2005 Ethiopia has been implementing an ambitious government-led low- and middle-income housing program: The Integrated Housing Development Program (IHDP). The initial goal of the program was to construct 400,000 condominium units, create 200,000 jobs, promote the development of 10,000 micro - and small - enterprises, enhance the capacity of the construction sector, regenerate inner city slum areas, and promote homeownership for low income households. As the five-year program nears completion, documentation of the program is timely Addis Ababa, the capital city, is relatively young having been established only one hundred and twenty years ago. It is located in the state of Oromiya and has a population of approximately 4 million, ten times larger than the second largest city in the country, Dire Dawa. In the past ten years Addis Ababa has risen from a city of self-built single-story homes, to a city of skyscrapers. This growth is set to continue as in the coming 15 years the population is projected to grow by 3.8 per cent per year17.

Currently the government of Ethiopia operates a housing programmed to address the high demand for affordable housing brought about by the fast growing rate of urban expansion, especially for households with low and medium incomes. The majority of citizens fall between these two categories as there are comparatively few high-income households.

The prominent current government approach to solving the low-income housing challenge is the Integrated Housing Development Program (IHDP), initiated by the Ministry of Works and Urban Development (MWUD) in 2005. The Program is a continuation of the Addis Ababa Grand Housing Program which supported the endeavors of the Ethiopian Government in their implementation of the Plan for Accelerated and Sustained Development to End Poverty’ (PASDEP).

The IHDP aims to:

a) Increase housing supply for the low-income population

b) Recognize existing urban slum areas and mitigate their expansion in the future

c) Increase job opportunities for micro and small enterprises and unskilled laborers, which will in turn provide income for their families to afford their own housing

d) Improve wealth creation and wealth distribution for the nation

To meet the above aims and to improve the construction industry Ethiopia government plan in the 2nd GDP to implement new technology which enhance the overall management system in preconstruction, construction and post construction in one modeling . This kind of collaboration design system allows us to quickly transport very accurate information for all stakeholder by accessing one model farther more able to analyze our energy models and practice various techniques that are required at the early stage of a project to confirm massing and help the architectural design process to progress and to perform with collaboration. This process which going to implement in the 2nd GDP plan in architecture, engineering, and construction (AEC) service providers is BIM with the main participation of public and private client. Building information modeling (BIM) is an intelligent model- based design process that adds value across the entire lifecycle of building and infrastructure projects.

Unlike CAD, which uses software tools to generate digital 2D and/or 3D drawings, BIM facilitates a new way of working: creating designs with intelligent objects. Regardless of how many times the design changes—or who changes it—the data remains consistent, coordinated, and more accurate across all stakeholders. Cross-functional project teams in the building and infrastructure industries use these model-based designs as the basis for new, more efficient collaborative workflows that give all stakeholders a clearer vision of the project and increase their ability to make more informed decisions faster. Models created using software for BIM are ―intelligent‖ because of the relationships and information that are automatically built into the model. Components within the model know how to act and interact with one another. A room, for example, is more than an abstract concept. It is a unique space contained by other building components (such as walls, floors, and ceilings) that define the room's boundary. With BIM, the model is actually a complex database and the room is a database element that contains both geometric information and non graphic data. Drawings, views, schedules, and so on are live views of the underlying building database. If designers change a model element, the BIM software automatically coordinates the change in all views that display that element—including 2D views, such as drawings, and informational views, such as schedules—because they are all views of the same underlying information. Project teams can also use information contained in the models to perform a variety of complementary tasks, including energy or environmental analysis, visualization, construction simulation, and improving the accuracy of documentation. In addition, BIM helps enable project teams to engage in innovative new contractual relationships and project delivery strategies, such as Integrated Project Delivery (IPD). Prefabrication reduces field labor cost and time and increases accuracy in a good quality construction. There are more tools and options readily available in a controlled environment of the jobsite to perform work more precisely, and less costly in a shorter period of time. So BIM have a lot of opportunity to additional power for the Ethiopia economy because the country economy in the 2nd GDP transfer from agriculture to industry as the result of this the construction industry transfer to prefabrication to provide the building materials off-site. But Prefabrication requires design and field accuracy. Building information models can provide this level accuracy by including the specifications, sequence, finishes, and the 3D visual for each component.

For the implementation of BIM, companies need to focus on an Implementation. A formal implementation strategy is an essential component of any successful BIM deployment and must go well beyond a simple training and rollout schedule. It needs to address head-on the work-flow and organizational changes inherent to BIM. The implementation strategy also needs to address how the new solution will initially exist with 2D drafting or 3D modeling applications already in use. Firms should look at how the building information model can be accessed by related applications such as energy analysis, cost estimating, and specifications.

Firms should pay close attention to the make-up of the transition team. The team should be comprised of progressive individuals who understand the big picture and will act as evangelists for BIM. Building information modeling can radically transform the process of designing, constructing, and operating a building. As can be seen, BIM offers many advantages and disadvantages to companies wanting to implement this product.

The advantages are very convincing, and the overall feeling is that they out way the disadvantages that have been identified. This is mainly due to the fact that most disadvantages are only being experienced due to the system being new, and are expected to become less as the system progresses.

The assistance of the public sector in the implementation of Building Information Modeling is of great importance. This is can be seen in all of the countries analyzed. Private sector has also made a large contribution to the implementation of BIM, and a cooperative effort is required between public and private companies to establish guidelines for the implementation of BIM in industry. So to Implement Building Information in our country and the collaboration between the public and private companies is necessary and also both the public and private companies are involved in the setting up of guidelines for the implementation of BIM. All countries have set up bodies that are involved in the setting up of guidelines, and mainly used experience gathered by both private and public companies on various projects to set up these guidelines. Public institutions like Universities are also playing a big role in the establishment guidelines and implement of BIM. Ethiopian Institute of Architecture, Construction Management and City Development (EiABC) started different research in BIM. One of the researches in this university in Ethiopia is applying Autodesk Revit®software in a ground-breaking initiative to digit and provides widespread access to the country’s architectural history.

The ambitious research is being conducted at the Ethiopian Institute of Architecture, Construction Management and City Development (EiABC) by the chair of CAD and geo-informatics. Ayele Bedada, Principal research conductor at the chair says: “Through conducting this research we intend to look back at our architectural heritage and trace its significance to the development of the local industry. Many attributes of our historic design have the potential to predict how Ethiopia’s design landscape evolves in the future.”

Over and above capturing the history, the project's main goal is to provide widespread digital access to Ethiopia's unique architectural and construction details.

This access is provided through a free, open-source plug-in for Autodesk Revit® that contains:

- Two-dimensional and high quality pictures of Ethiopian construction material textures, construction technique patterns and background images.
- Three dimensional and parametric models of Ethiopian construction material details, Ethiopian house design types and indigenous plants (including a selection of trees and landscape elements).

Bedada adds: "By making these objects available to emerging Ethiopian professionals in precise and practical ways, we will assist in advancing the Ethiopian industry of architecture and construction."

The project began three years ago, when Bedada prepared the initial research. It has now expanded to involve several members of academic staff and a number of interested students.

"The Building Information Modeling (BIM) methodology was a source of inspiration during the modeling phase of the research. Since Autodesk Revit ® is a leader in this field, it was used to great success in the implementation of this stage to produce parametric models of traditional Ethiopian architectural details. In our country case public university like EiABC has played a major role in the implementation of Building Information Modeling.

4. 2 PROJECT ANALYSIS DISCUSSION

In section tries identify inefficient housing sector with luck of structured work plan highly affect the integrated housing development program and understand the uses, opportunity and challenge of BIM for construction managers for Addis Ababa Housing Development project The research was conducted through literature review, journals, and interviews. In order to assess the cases, interview along with desk study of the relevant documents has been used.

Interview

It is evident that interview is one of the primary data collection methods which is flexible and adaptive way of investigating underlying motives of a subject in a way that self-administered questionnaires cannot provide. The interview undertaken for this project was based on semi structured style. The interview for this paper was made with five selected organization like private contractor and consultant in addition to this public organization: EiABC (A.A University), Ministry of urban development & Housing and Ethiopia construction project management institute reputable and higher level professionals. From these interviewed professionals, two of them are from contractor side, the two others are from consultant sides and the remaining one is from the public organization.

Desk Study

Desk studies try to fill this void, this dissertation attempted to analyses BIM from the Project Management point of view. The research started with the mission to answer a double research question: What is the knowledge structures underlying the BIM domain? How can these knowledge structures be harnessed to assist industry stakeholders to adopt BIM or improve their BIM performance considering case study of Addis Ababa housing project? To answer this, the study try to analyze relevant literature, analyzed the benefits of implementing BIM in different country and reviewed the opinions of private contractor and consultant in addition public organization professionals collected through interview. For this reason, desk studies under this project are used to supplement the findings obtained through interview but most of the respond they do have Lack of knowledge about BIM as the result of this only table discussion done instead of the data analysis.

The literature showed a need for better integration of project teams and collaboration between all parties. It also showed the need for a new way of dealing with information, moving from the document paradigm to the Project Integrated Database paradigm. The information analyzed pointed in the direction that BIM could be the tool that allowed this better integration of teams and of information. The research study pursued based on that has shown that it does, with Communication and Coordination as two of the Key Performance Indicators (KPIs) showing more benefits due to the use of BIM in construction projects. So the result of interview shown in the flowing discussion table:-

DISCUSSION TABLE

INTEVIWED ORGANIZATIO	INTERVIWE QUESTIONS	RESPOND
PRIVATE CONTRUCTOR	What Do You Know About Bim And It's Implementation	Lack of knowledge on how to implement BIM.
PRIVATE CONSULTANT	What Do You Know About Bim And It's Implementation	Lack of knowledge on how to implement BIM.
MINISTRY OF URBAN DEVELOPMENT AND HOUING	What Do You Know About Bim And It's Implementation	Lack of knowledge on how to implement BIM. - Launched short courses and the training

ETHIOPIA CONSTRUCTION PROJECCT MANAGEMENT INSTITU	**Any Trailing Or Conducting Research In Bim Implementation**	**-Engaged various tertiary institutions to include BIM Training in their curricula and student also Engaged to do research in this area. - ECPMI now invites eligible bidders, for the supply, installation and training of a 3D Building information modeling (BIM). -ECPMI has secured sufficient budget from the Government of the FDRE and World Bank (Urban Local Government Development Program II). -Bidding will be conducted through the International Competitive Bidding (ICB).**
ETHIOPIA CONSTRUCTION PROJECCT MANAGEMENT INSTITU	**Benefit Of Bim Implementation**	**-Ensure effective implementation of the country's short and long term construction programs and projects in terms of time, finance and quality through building project Management. -Changes done at design level -Conflict will eliminate during construction time. - Time saving -cost saving & advanced cost control. - Encourage prefabrication etc…**
ETHIOPIA CONSTRUCTION PROJECCT MANAGEMENT INSTITU	**Challenge Of Bim Implementation**	**- legal barriers -change the familiar delivery system. - change the organizational structure**
ETHIOPIA CONSTRUCTION PROJECCT MANAGEMENT INSTITU	**Knowledge Structures Underlying The Bim**	**-Different engineering software like Autodesk Rivet software**
EIABC	**Any Trailing Or Conducting Research In Bim Implementation**	**-Trailing for city administration -Two researches ongoing in EiABC to implement in Ethiopia. "cheer of appropriate building technology"**

EIABC	**Benefit Of Bim Implementation**	**Almost 80% of the building model done with very good precise during design time with Corporation work b/n ARC. Engineer, Mechanical, electrical plumbing because every designer work going to clash this result :** **-Changes done at design level** **-Conflict will eliminate during construction time.** **- Time saving** **-cost saving & advanced cost control.** **- Advanced quality result** **- Data & information fast** **- Encourage prefabrication etc…**
EIABC	**Challenge Of Bim Implementation**	**-Awareness about BIM in the city administration office and other public office** **-Availability of software** **- Lack of knowledge on how to implement BIM** **- Lack of ready pool of skilled BIM manpower** **-Lack of demand for BIM** **-Legality of the software.**
EIABC	**Knowledge Structures Underlying The Bim**	**-Different engineering software like Autodesk Rivet software**

Table 2: Discussion Table

CHAPTER FIVE

5. CONCLUTION AND RECOMMENDATION

5.1Conclution

In this study, the concept of BIM, this has a great impact and importance in the construction industry. In this context, refereed journal articles including “BIM” and/or “Building Information Modeling” in their title and/or keywords are discussed in terms of different dimensions to evaluate the research tendency and gap in BIM literature. The results of this project to show Changing from the traditional approach to Building Information Modeling (BIM) implementation is not an easy process. It includes decision making and the change in management strategies.

By doing this, all parties will submit their model based on the agreed model format and it is easier for the organizations to access the model. Recognition and support from the government are still low, but currently the government tries to improve the productivity of the construction industry. This one of 2nd GDP plan to implement BIM in Public construction. From the interview FDRE get started by ECPMI, to invites eligible bidders internationally which fulfill the following requirements, to submit sealed bids for the supply, installation and training of a 3D Building information modeling (BIM).Due to the lack of knowledge of BIM and the low level of BIM uptake by the Ethiopian construction Players, the implementation of BIM in the Ethiopia construction industry. Even if there are still a few problems associated with the implementation of BIM like Availability of software, Lack of knowledge on how to implement BIM Lack of ready pool of skilled BIM manpower Lack of demand for BIM Legality of the software.

We conclude here with some final observations and predictions about the changes to occur over the next five to ten years:

- Private companies in our country do not show cooperative effort with public body to implement BIM.
- From the above discussion table ,there is only few public instruction in Addis Ababa start to aware about implementation of BIM ,by conducting research and facilitate international bid for supply the software and tailing .
- I believe will be likely implementation of the full integration of digital tools, through the use of building information models, in Addis Ababa housing project is important to satisfy the demand house by using the overall opportunity of BIM process in years to come 2nd GDP.

5.2 Recommendation

- To satisfy the highest housing demanded in long run Addis Ababa housing project should take beg attention to implement BIM because of every change and influence of cost done during the design phase so as to eliminate the conflict during construction phase and change.
- Even if there are still a few problems associated with the implementation of BIM like Availability of software, Lack of knowledge on how to implement BIM, Lack of ready pool of skilled BIM manpower Lack of demand for BIM Legality of the software, I recommend to start with the implementation as early as possible, as the catching up at later stage may become very costly.
- Public institutions like Universities should play a big role in the establishment of BIM guidelines.
- Public Institute should keep work hard to implement BIM in Addis Ababa housing to satisfy the demand in the long run.

Finally, I recommend further research study in this new area to be conducted by interested researchers.

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